Commercially Viable Process for Surface Conditioning of High-Nickel Low-Cobalt Cathodes

BAT # 557

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Annual Merit Review and Peer Evaluation Meeting (*June 21-23, 2022*)

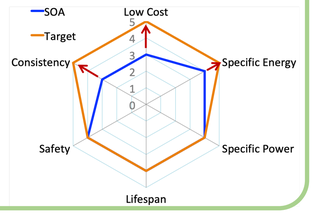
Project Overview

Timeline
- Project start date
  - October 1, 2020
- Project end date:
  - September 30, 2022

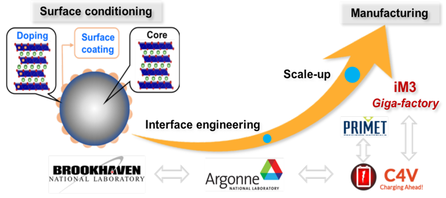
Barriers
- Consistency: from lab scale to pilot scale
- Cost: feedstock/material, capital and processing costs
- Performance: specific energy, cycle life

Relevance and Objectives

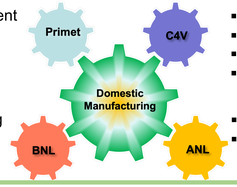
- **Project Goal** To demonstrate a commercially viable process for large-scale production of surface stabilized high-Ni low-Co cathodes, with high consistency, low cost, and high specific energy.
- Develop a scalable surface conditioning process for producing high-Ni low-Co cathode active materials (CAMs).
- Demonstrate the high performance of CAMs:
  - specific energy 700 Wh/Kg;
  - < 20% fade in 1000 cycles;
  - 250 Wh/Kg at the cell level (in large-format 5 Ah full cells).
- Demonstrate the high consistency of the scaled-up materials (up to 500 g).



Approaches



- Precursor Development
- Particle Engineering
- Process-upscaling
- Synthesis/Processing
- Diagnostics

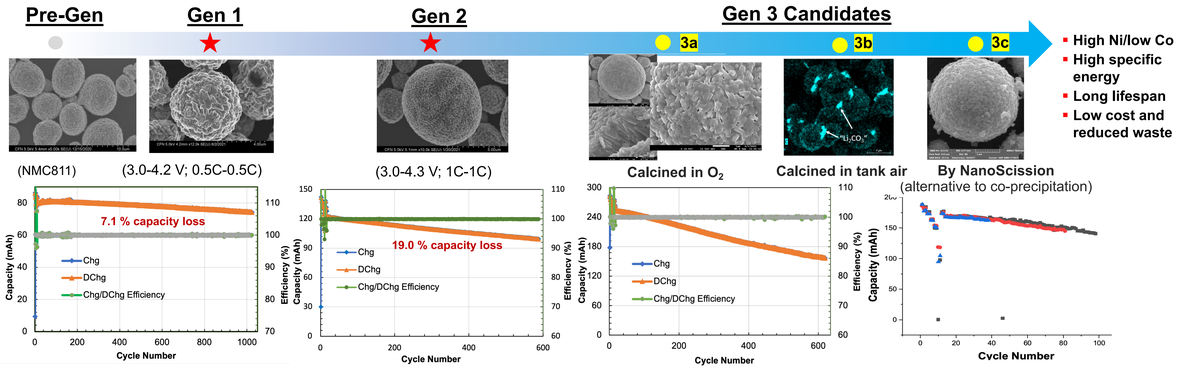


- Benchmarking
- Supply Chain
- Cell Prototyping
- Manufacturing (*GWh scale*)
- Interface Electrochemistry
- Interface Engineering

Milestones

Quarters	Description (*status*)
Q1	Complete synthesis/processing of Gen 1 candidates (*completed*)
Q2	Benchmark of the Gen1 (*completed*)
Q3	Complete synthesis/processing and down-selection of Gen 2 (*completed*)
Q4	Complete optimization and scale-up of the selected Gen 2 (*completed*)
Q5	Selection of Gen 3 candidates from the materials at varying stages of development (*completed*)
Q6	Optimization of the selected Gen 3 candidates (*completed*)
Q7	Down-selection and scaling of the Gen 3 candidates (*in progress*)
Q8	Final evaluation of the Gen 3 in large-format cells (*on track*)

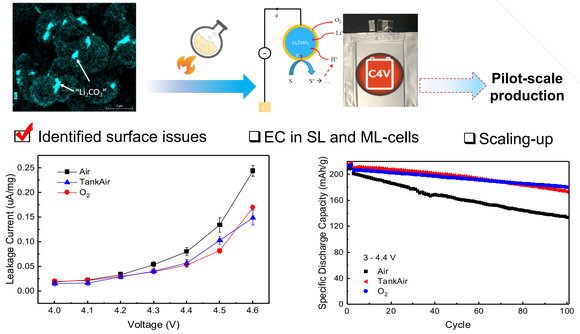
Accomplishments



➢ **Gen 1 and 2 candidates**: exceeded the performance targets.

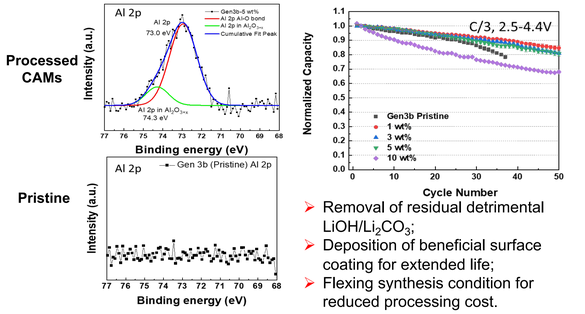
➢ **Gen 3 candidates**: selected 3a-c at different development stages.

Gen 3b



➢ Li_2CO_3 is the primary contributor to parasitic reactions.

☑ Process developed to convert detrimental surface residual into beneficial coating

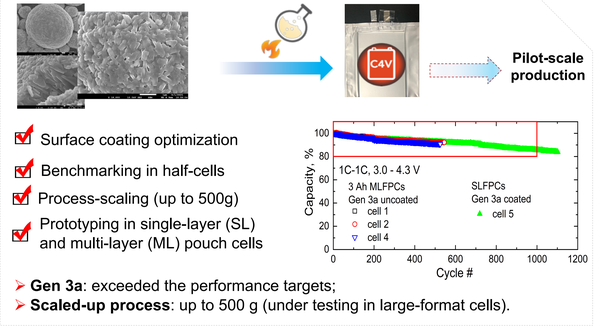


➢ Removal of residual detrimental LiOH/Li_2CO_3;

➢ Deposition of beneficial surface coating for extended life;

➢ Flexing synthesis condition for reduced processing cost.

Gen 3a

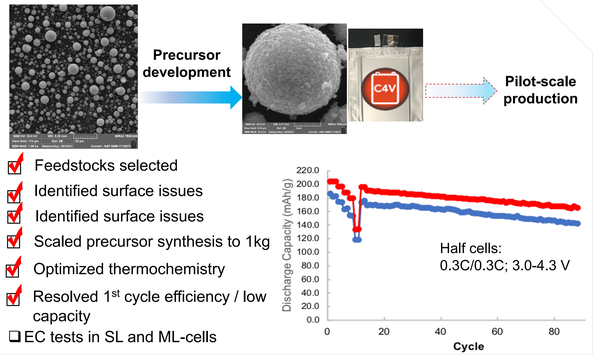


☑ Surface coating optimization
☑ Benchmarking in half-cells
☑ Process-scaling (up to 500g)
☑ Prototyping in single-layer (SL) and multi-layer (ML) pouch cells

➢ **Gen 3a**: exceeded the performance targets;

➢ **Scaled-up process**: up to 500 g (under testing in large-format cells).

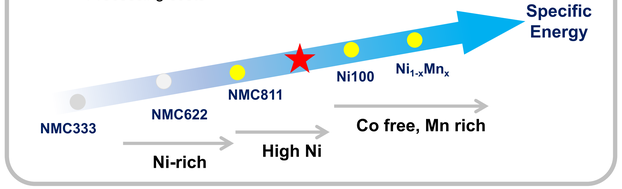
Gen 3c



☑ Feedstocks selected
☑ Identified surface issues
☑ Identified surface issues
☑ Scaled precursor synthesis to 1kg
☑ Optimized thermochemistry
☑ Resolved 1st cycle efficiency / low capacity
❑ EC tests in SL and ML-cells

Remaining Challenges

- Process scaling-up to the commercial scale (in tons)
  - Fundamental issues in calcination: heat flow, oxygen diffusion, water evaporation,…
  - From batch to continuous production
  - Process control for each of involved steps: quantification on the yield, cost, …
- Growing demands on energy density (*300+ Wh/Kg*), sustainability and cost
  - Ni-based Co-free cathodes to address manufacturing needs, while bringing challenges:
    - Cycling/thermal stability
    - Processing costs



Summary

- Developed processes for producing surface-stabilized high-Ni low-Co CAMs;
- Demonstrated high-performance Gen 1-3 CAMs: with performance exceeding the targets;

Generation	Specific energy (Wh/Kg)		Lifespan
	Electrode level	Cell level	(*<20% fade*)
☑ Gen 1	>600		1000
☑ Gen 2	>700	250Wh/kg	500
☑ Gen 3	> 700	250Wh/kg	1000

- Demonstrated the high consistency of the scaled-up materials (up to 500 g);

➢ **Next step:** process upscaling to pilot and industrial scales for commercial production.

Lab-scale: ~ 1-10 g (2021) ⇨ **100 g – 1 Kg** (2022) ⇨ **100 Kg – 5 Ton** (2023)

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